AD 414516

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION, ALEXANDRIA, VIRGINIA

AFCRL-63-817

THE PENNSYLVANIA
STATE UNIVERSITY

IONOSPHERIC RESEARCH

Scientific Report No. 192

SOME FEATURES OF THE F REGION ELECTRON DENSITY AND HEIGHT VARIATIONS IN THE EQUATORIAL REGIONS

by

Y. V. Somayajulu

September 1, 1963

The research reported in this document has been sponsored by the Geophysics Research Directorate of the Air Force Cambridge Research Laboratory, Air Research and Development Command, under Contract AF19(604)-4563 and, in part, by the National Science Foundation under Grant G-18983.

IONOSPHERE RESEARCH LABORATORY

University Park, Pennsylvania

Contract No. AF19(604)-4563
Project 8605, Task 860502

AFCRL - 63-817

Ionosphere Research

Contract AF19(604)-4563

Scientific Report

on

"Some Features of the F Region Electron Density and Height Variations in the Equatorial Regions"

by

Y. V. Somayajulu

September 1, 1963

Scientific Report No. 192

(Project 8605, Task 860502)

"The research reported in this document has been sponsored by the Geophysics Research Directorate of the Air Force Cambridge Research Laboratory, Air Research and Development Command, under Contract AF19(604)-4563 and, in part, by the National Science Foundation under Grant G-18983."

IONOSPHERE RESEARCH LABORATORY

Approved for Distribution

A H Waynick

A. H. Waynick, Director, I.R.L.

THE PENNSYLVANIA STATE UNIVERSITY

College of Engineering

Department of Electrical Engineering

Table of Contents

Abstract

In this report are presented the average quiet day variations in NmF and h(.9NmF) for the equatorial stations Talara and Huancayo, derived from the true-height profiles for the five international quiet days for each of the IGY months. The results show that the forenoon and evening slopes of the Nm(t) curves, as well as the post-sunset increase in the F region heights, have similar semiannual variations. It is established that this semiannual variation has a close correlation with the variation of the cosine of the noon solar zenith angle of the sun, indicating that electrodynamic drifts are important in producing the observed seasonal variation. It is shown that vertical drifts alone are inadequate to account for the large slopes in the Nm(t) curves. It is established that east-west drifts, such as those observed experimentally, can cause large variations in these slopes. A seasonal variation of the wind pattern may account for the observed seasonal variation.

On this model the phenomenon of the post sunset increase in F region heights, and its seasonal variation, is explained. It is indicated that several other equatorial phenomena such as Spread F and flutter fading can be explained on this basis. It is concluded that, in the equatorial regions, the ionospheric electrostatic fields play a dominant part in causing the equatorial 'anomalies'.

1. Introduction

The F region in equatorial and low-latitude regions is known to exhibit several anomalous features with regard to the maximum electron density, NmF, as well as the height of the maximum (Appleton, 1946; Osborne, 1951). For example, there is a belt of low values of NmF centered around the dip equator, and the NmF shows a midday bite-out phenomenon. Several peculiar propagation phenomena such as flutter fading (Subba Rao and Somayajulu, 1949), the far-eastern anomaly in scatter propagation (Smith and Finney, 1960) etc., are also associated with these latitude regions. Recently Appleton (1960) pointed out that in the equatorial belt of $\pm 20^{\circ}$ (magnetic latitude) the h'F shows a characteristic post-sunset rise during the years of high sunspot activity.

Although a wealth of data and analyses of NmF are available it has only recently become possible to study the true heights of the F region (see for example Thomas 1959). Thus many of the virtual height variations have to be reexamined, using true height data, for a proper understanding of the basic mechanisms that can cause the phenomena. The aim of this report is to present and interpret some results obtained using the N(h) profiles for the IGY period for two equatorial stations Talara (dip 13°N) and Huancayo (dip 1°N) which lie approximately along the 75°W meridian.

2. Data and Analysis

The hourly ionograms for these stations are reduced to N(h) profiles using a digital computer (Schmerling, 1957). The mean diurnal variations in NmF and h(.9NmF) for quiet days are derived from averaging the data for the five international quiet days in each month. The diurnal variations in height for some selected storms in this period are also analysed.

3. Results

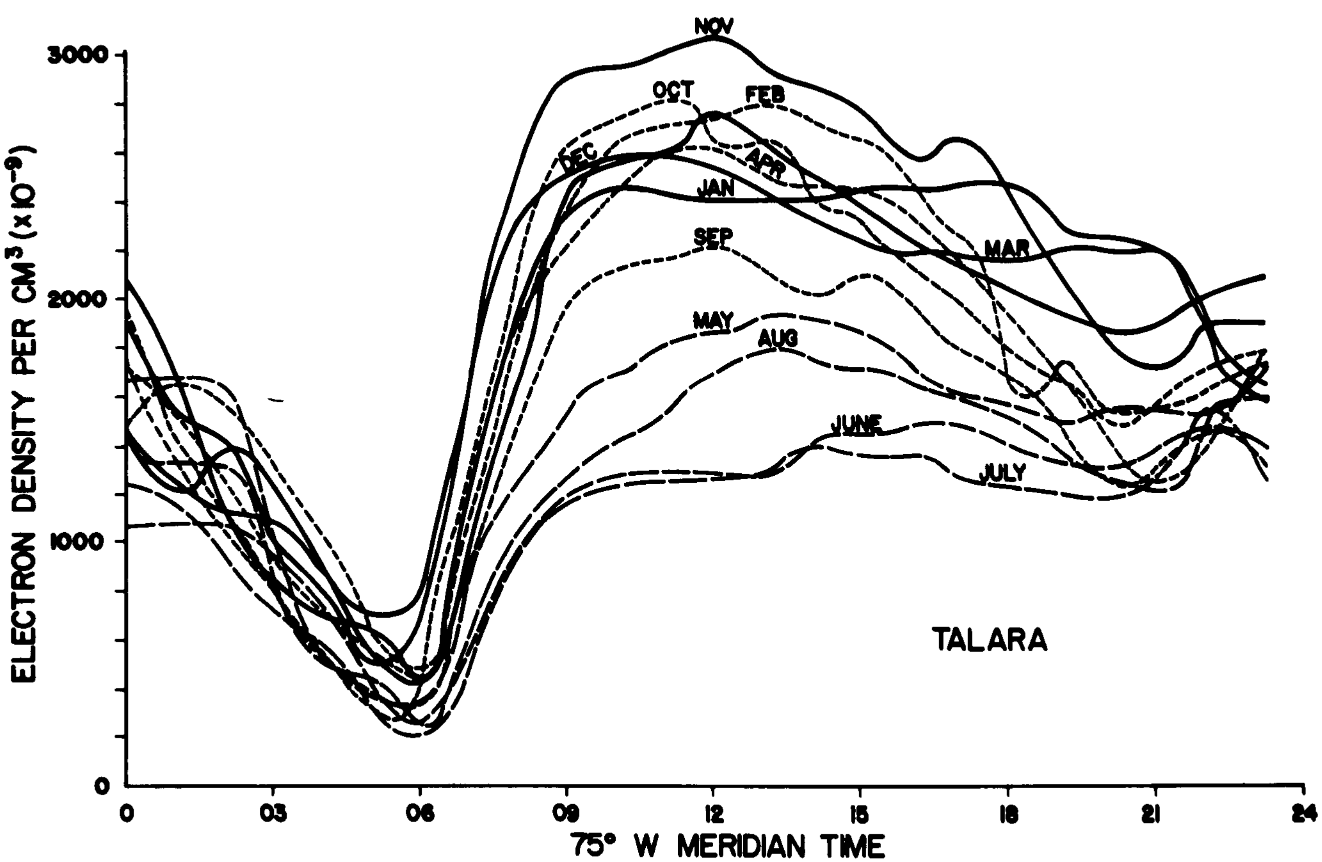
3.1 Mean quiet day behavior of NmF

The mean quiet day diurnal variations of NmF for twelve IGY months are shown in Figs. 1 and 2. It is immediately evident that the daytime NmF values during winter months are higher than those for summer months. This is a well-known feature although it has not as yet been satisfactorily explained.

The general trend of the Nm(t) curve in Figs. 1 and 2 shows the following interesting features:

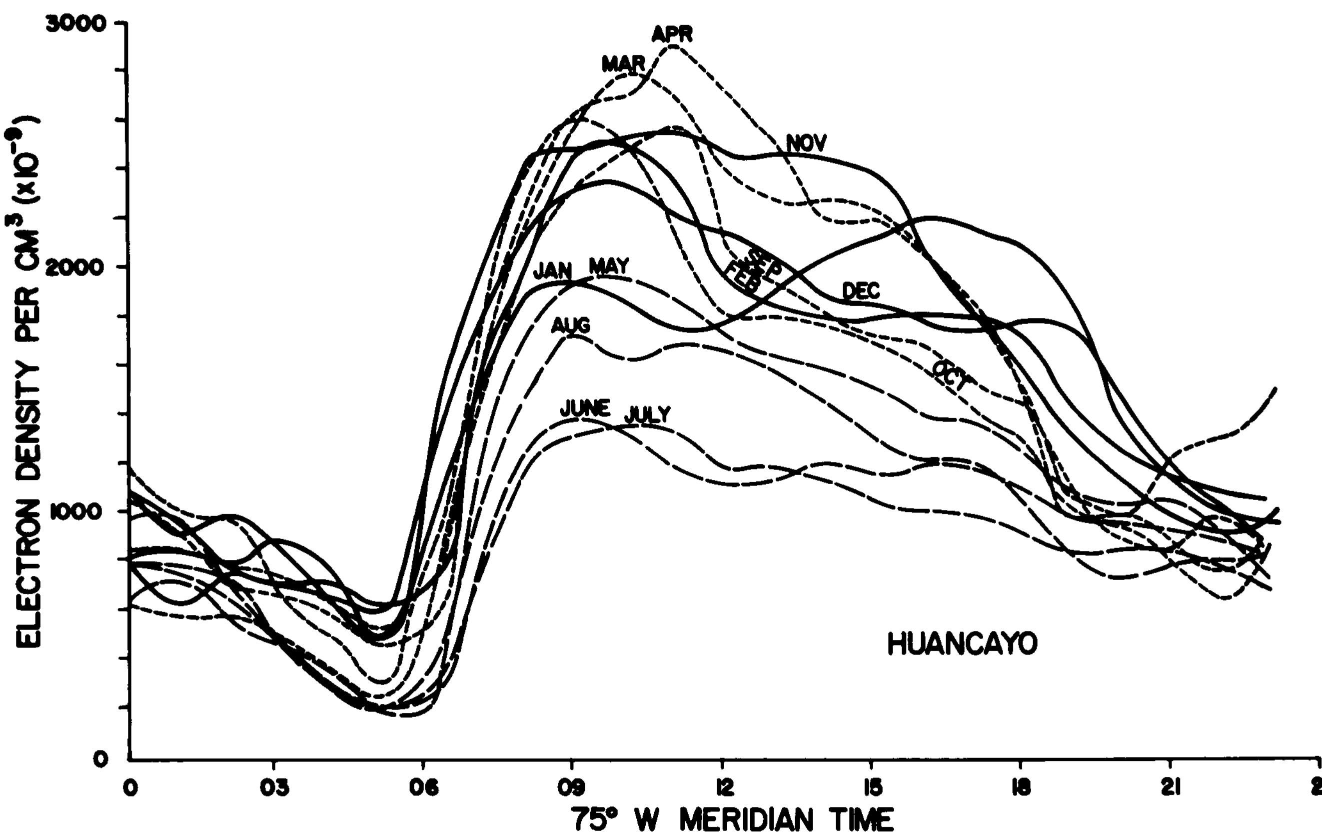
(1) Sunrise dip: There is a characteristic dip in NmF around sunrise. The minimum value reached is lower during local winter than in local summer.

(2) Forenoon increase: Following the sunrise dip, NmF rather steeply increases to reach a maximum before noon. The slope of the forenoon Nm(t) curve shows a semiannual variation that is correlated with the noon value of solar zenith angle at both the stations (Schmerling, 1962).



MEAN QUIET DAY VARIATION IN NmF AT TALARA FOR 12 IGY MONTHS

FIGURE 1



MEAN QUIET DAY VARIATION IN NmF AT HUANCAYO FOR 12 IGY MONTHS

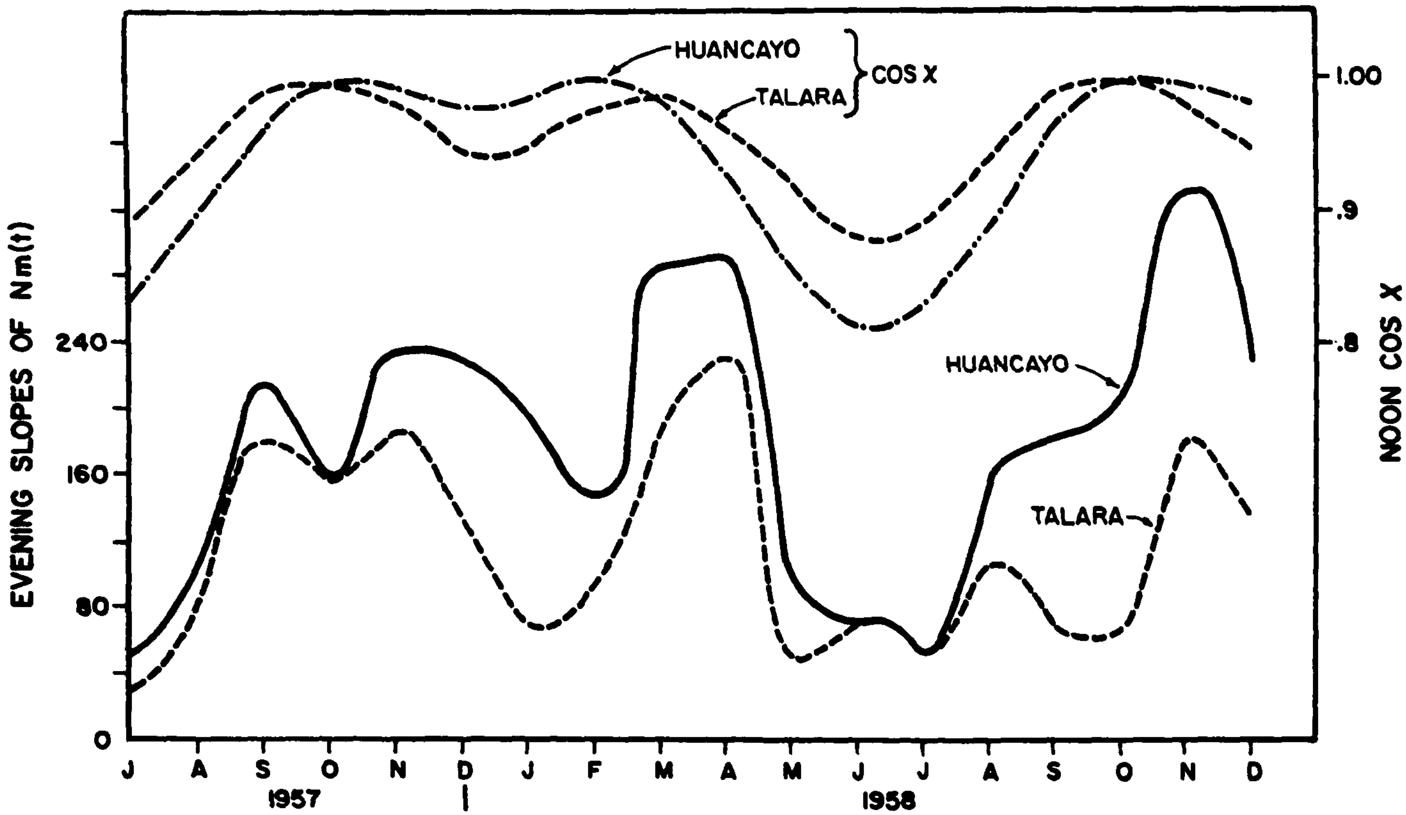
FIGURE 2

(3) Evening decrease: In the evening NmF decreases to a minimum value just after sunset. The slope of the evening Nm(t) curve, as well as the minimum value of NmF reached after sunset, have a seasonal dependence. The lowest values of the latter occur around the equinoxes. The average slope of the Nm(t) curve preceding the sunset minimum has been computed and is plotted in Fig. 3. On the same Figure the variations of the noon value of cos χ for both stations are also shown. It is seen that the slopes are maximum during the equinoxes when the lowest post-sunset dip in NmF is reached. The semiannual variation in the evening slopes is seen to be well correlated with the noon solar zenith angle.

3.2 Mean quiet day behavior of h(.9NmF)

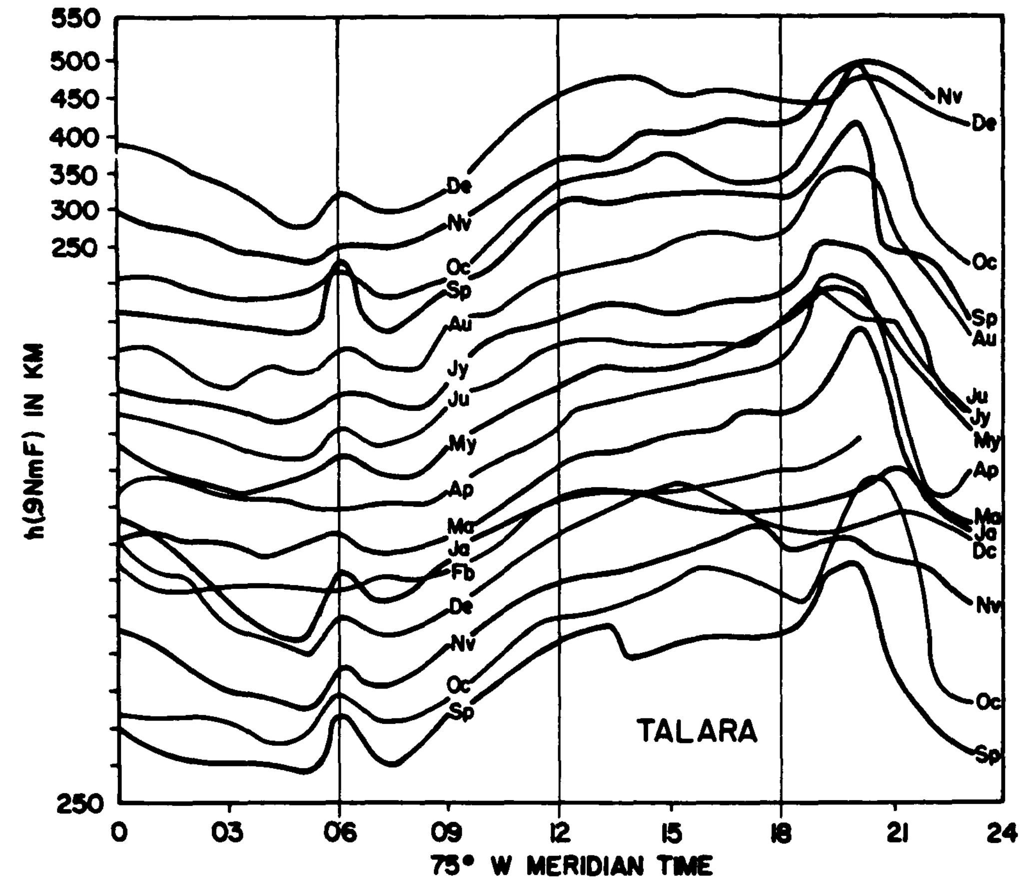
In Figs. 4 and 5 are plotted the average diurnal variation in h(.9NmF) at the two stations for the IGY months. These figures reveal that, at both the stations, the daytime heights are greater in winter than in summer, thus showing an inverse correlation with the NmF values described in the previous subsection. At Talara the height difference is about 50 km while at Huancayo it is about 100 km.

Two characteristic diurnal phenomena are noted, namely a sunrise increase and a post-sunset increase in the F region heights. Previously Appleton (1960), analysing the equinoctial h'F data for the IGY, drew attention to these phenomena as characteristic of the equatorial regions. The evidence on true heights presented here confirm these. It has been



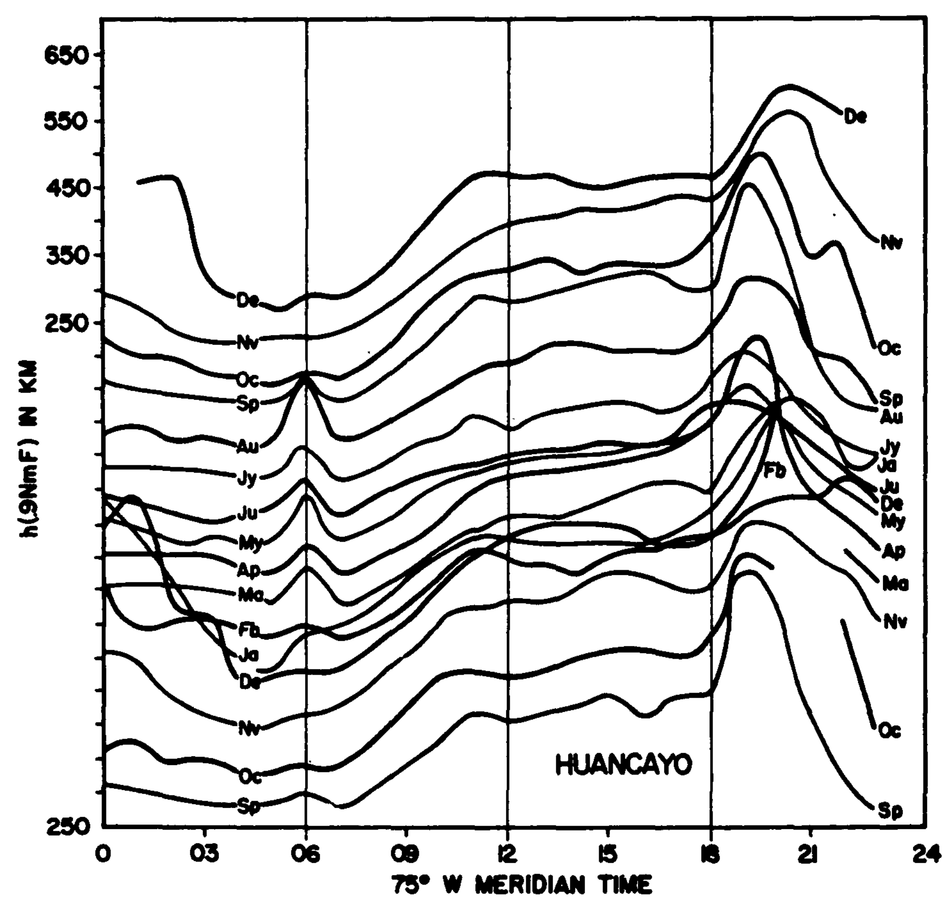
SEASONAL VARIATION OF THE EVENING SLOPES OF THE Nm(t) CURVE FOR TALARA AND HUANCAYO

FIGURE 3



MEAN QUIET DAY VARIATIONS IN h(.9NmF) AT TALARA FOR IGY MONTHS

FIGURE 4



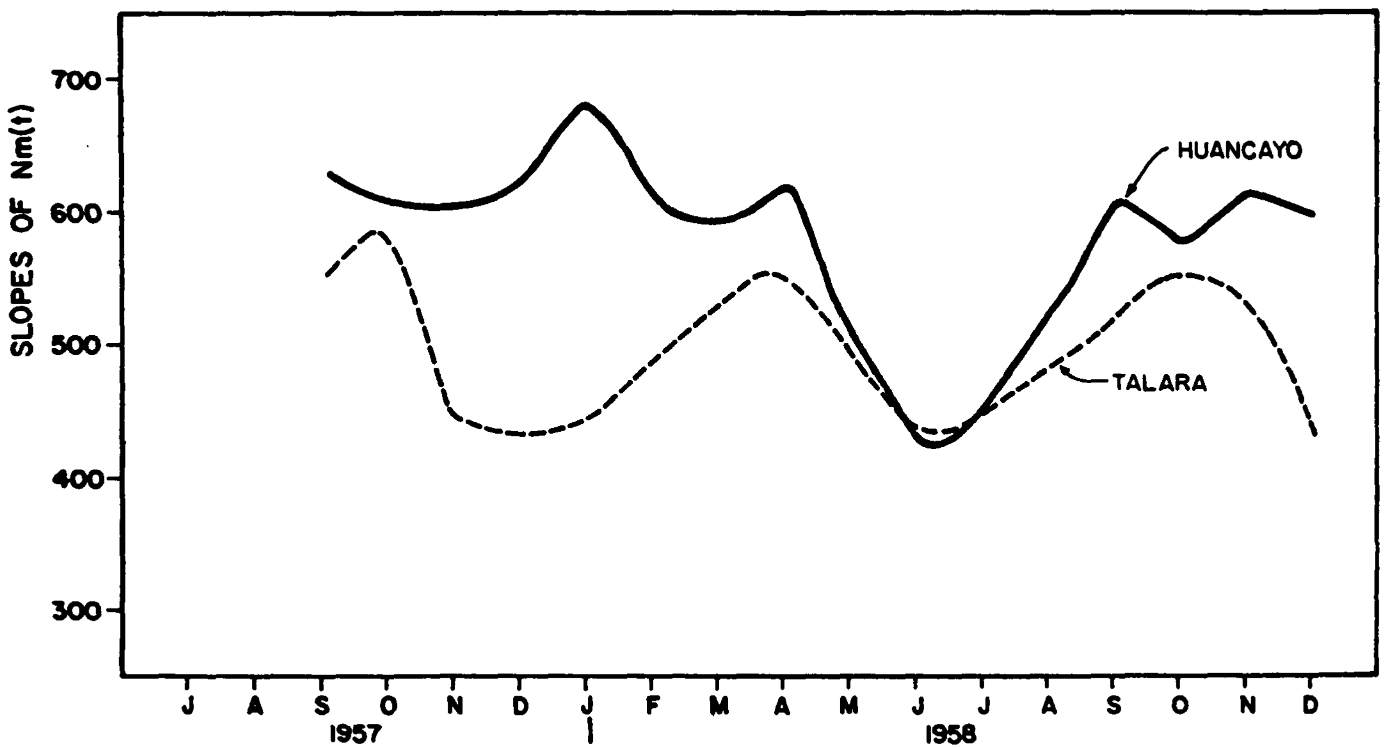
MEAN QUIET DAY VARIATIONS IN h(.9NmF) AT HUANCAYO FOR IGY MONTHS

FIGURE 5

observed (Appleton, 1960; Rao, 1962) that the post-sunset rise in h'F only occurs during periods of high sunspot activity. It is also found to depend on the magnetic dip of the observing station, the magnitude decreasing with increasing dip, and being barely noticeable outside of the equatorial belt of $\pm 20^{\circ}$ (magnetic latitude) from the equator. The results given here are consistent with these findings.

It may be noted from Figs. 4 and 5 that both the sunrise increase and the post-sunset rise in heights show a strong seasonal dependence. The sunrise increase is observable from March through September; it is practically absent during local summer. The maximum amplitude is about 40-50 km and is reached around the vernal equinox.

In Fig. 6 the seasonal dependence of the post-sunset increase in height at the two stations is shown. There is a semiannual variation very similar to that of the sunrise and evening slopes of the Nm(t) curve. At Talara there are two equinoctial maxima with minima occurring around the soltices. Huancayo also shows this semiannual variation; however, the December minimum is very shallow with a small peak around January. At first sight this difference in the behavior of the two stations may appear a little anomalous but this is very likely due to the difference in the annual and semiannual components at the two stations. This is possibly due to an annual variation that has a larger amplitude at Huancayo.



SEASONAL VARIATION OF THE POST SUNSET RISE IN HEIGHTS AT THE EQUATORIAL STATIONS FOR THE IGY PERIOD

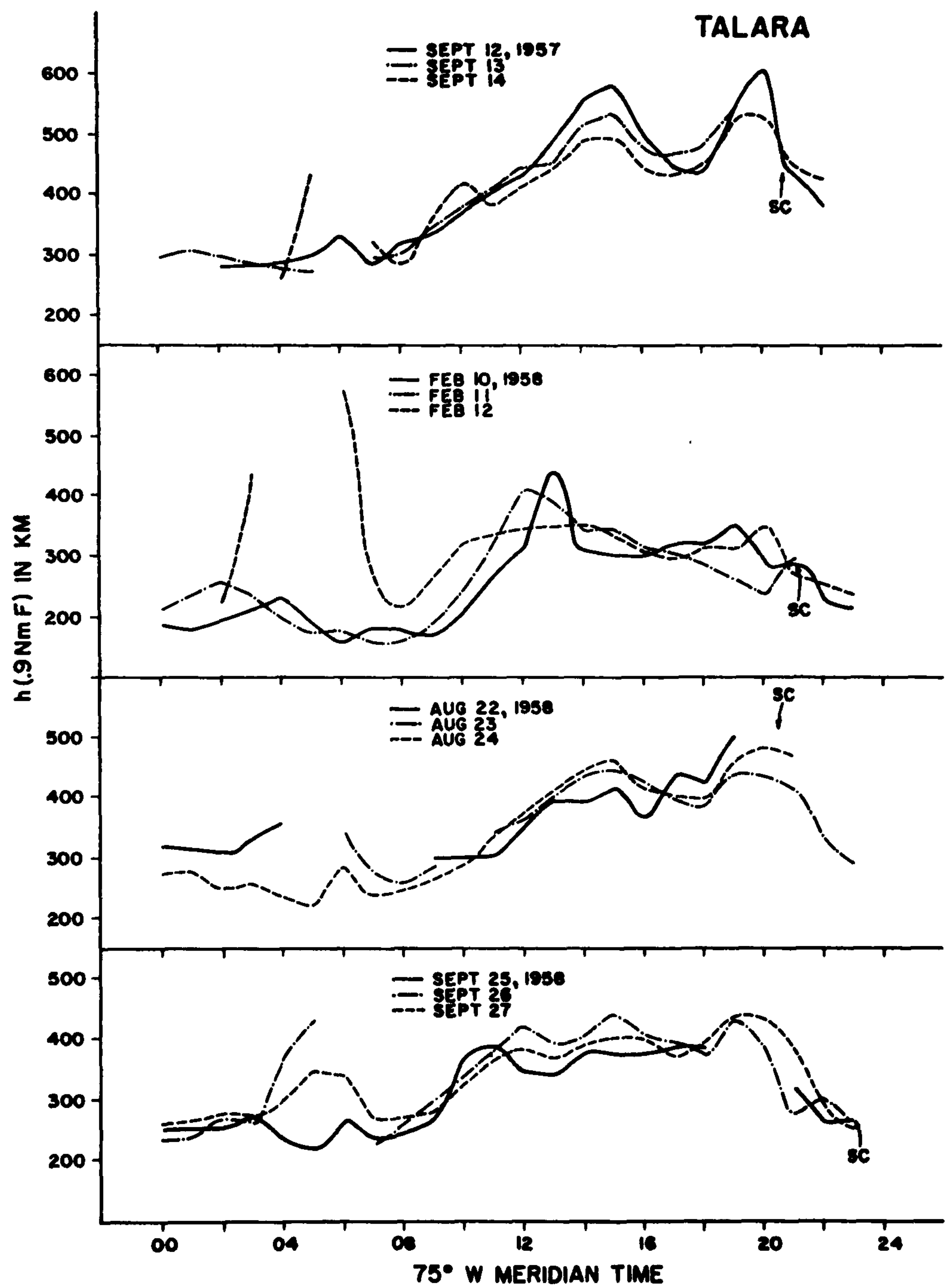
FIGURE 6

Comparing the curves in Fig. 6 with the cos χ variation plotted in Fig. 3 we find that the post-sunset rise is also well correlated with the noon solar zenith angle. It is seen that the annual component in the cos χ variation at Huancayo is larger and this causes the December minimum to be shallower.

We, thus, establish that the NmF and height features in the equatorial regions show a seasonal dependence that is well correlated with the noon solar zenith angle. Since the noon solar zenith angle determines the location in latitude of the foci of the S_q current system we may infer that electrodynamic drifts play an important, if not a dominant, part in causing the seasonal variations of NmF and heights reported here.

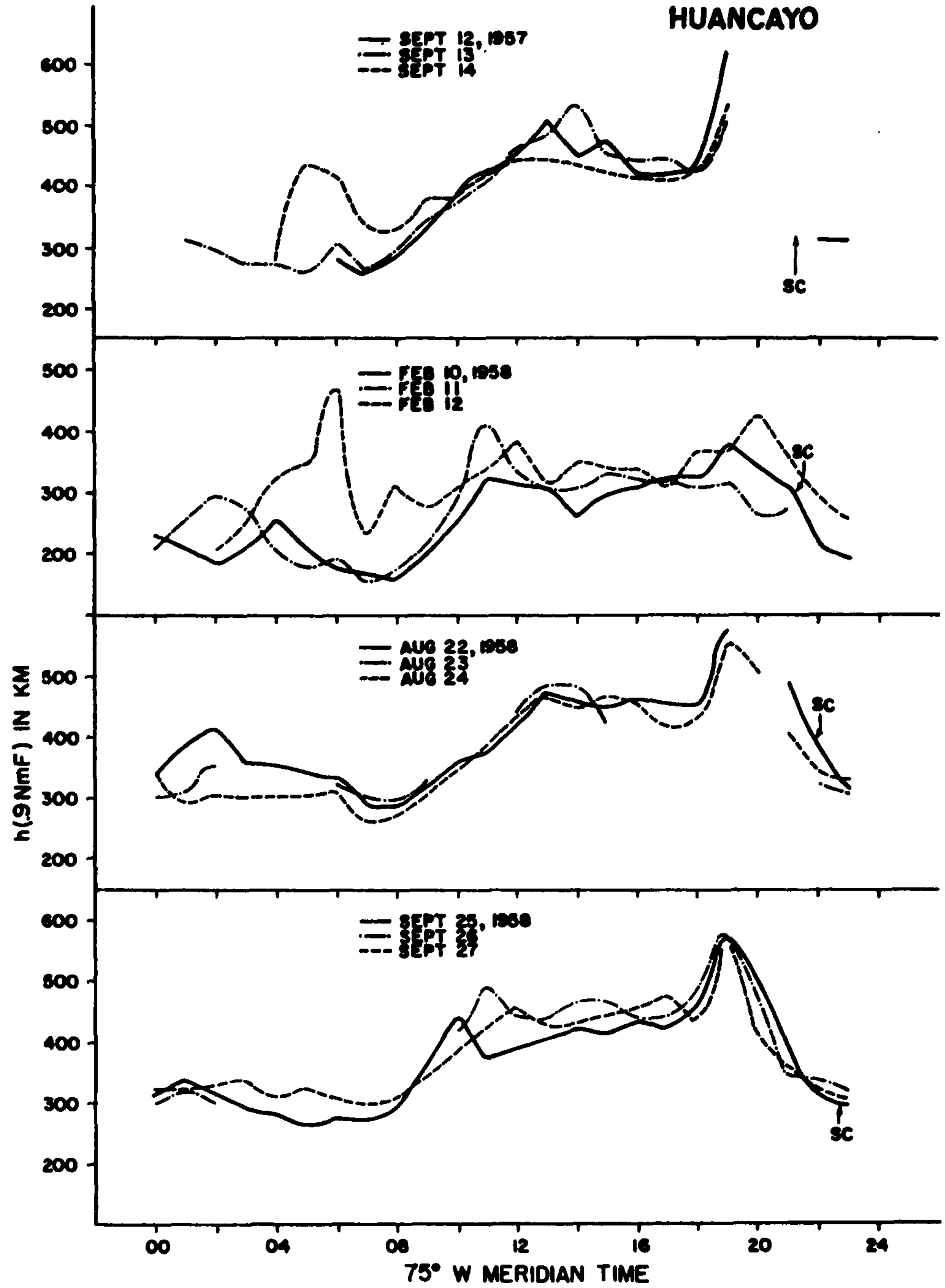
3.3 Height changes during disturbed days

The height changes during strong individual storms have been presented elsewhere (Somayajulu, 1963). In this section some interesting features of the disturbances on the sunrise and post-sunset height variations will be presented. The diurnal height variations associated with several severe storms during the IGY period are studied. The storms have their sudden commencement during the night. Some examples of the height curves are shown in Figs. 7-8. It is seen from the curves that both the sunrise increase as well as the post-sunset rise in height are affected by the storms but in opposite ways. The pre-sunrise increase is



DIURNAL VARIATIONS IN h(.9NmF) AT TALARA DURING DISTURBED DAYS

FIGURE 7



DIURNAL VARIATIONS IN h(.9NmF) AT HUANCAYO DURING DISTURBED DAYS

FIGURE 8

considerably enhanced during disturbed days while the post sunset increase is reduced in magnitude. In the case of the strongest storms the reduction in post-sunset increase in height is of the order of 60 km. It is also interesting to note that during the strong storms the midday heights at both Talara and Huancayo are lower than on quiet days.

4. Discussion

4.1 Distortion of the N(t) curve by electrodynamic Drifts

The time variation of N is governed by the equation of continuity

$$\frac{dN}{dt} = q - \beta N - \mathrm{div}(NV) - D \qquad (1)$$

where

q = production rate

β = loss coefficient

v = drift velocity

D = diffusion term.

At low latitudes the diffusion term may usually be set equal to zero. Any horizontal diffusion that may be present may be taken care of by interpreting the appropriate $\mathrm{div}(Nv)$ terms to include such effects.

Expanding the divergence term, equation (1) may be rewritten

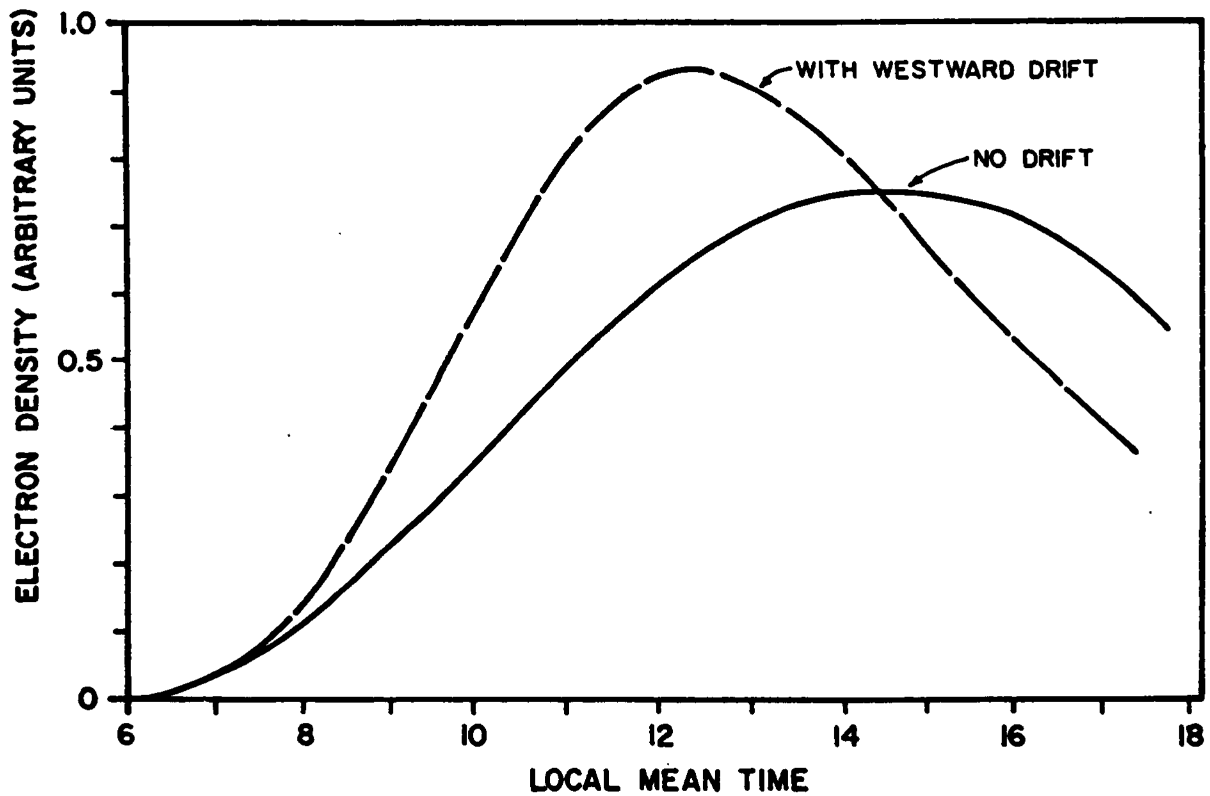
$$\frac{dN}{dt} = q - \beta N - \vec{V}\cdot \mathrm{grad}N - N\mathrm{div}\vec{V} \qquad (2)$$

Because the relaxation time of the F region is of the order of an hour or more, $(q - \beta N)$ is positive during the forenoon and negative during the afternoon and this quantity mainly determines the nature of the slope of the N(t) curve. In the absence of drifts and diffusion the nature of the N(t) curve one might expect is shown by the solid line in Fig. 9. It has, however, been observed that the N(t) curve in the equatorial regions shows a midday bite-out with two peaks; one in the forenoon and another in the afternoon (Maeda, 1955). Sarma and Mitra (1956) in studying the bite-out phenomenon observed the forenoon and afternoon NmF2 peaks show magnetic dip and sunspot control. The forenoon peak increases with increasing sunspot activity while the afternoon peak behaves in the reverse manner.

The distortion in the N(t) curves in the equatorial regions is attributed to the presence of vertical drifts. These arising from the interaction with geomagnetic field of the electrostatic field associated with the dynamo region and transmitted to the F region through the highly conducting geomagnetic lines of force (Martyn, 1947).

The geomagnetic distortion of the F2 region by vertical electrodynamical drifts has been discussed by several workers; notably by Hirono and Maeda (1954). These authors assumed the following form of the drift term as deduced from the geomagnetic variations

$$W = f(R) \left[W_1 \text{ Sin } (\lambda + \theta_1) + W_2 \text{ Sin } (2\lambda + \theta_2) \right] \quad (3)$$



EFFECT OF HORIZONTAL (WESTWARD) DRIFT ON THE SHAPE OF THE Nm(t) CURVE.

FIGURE 9

Where W_1 and W_2 are the amplitudes and θ_1 and θ_2 are the phases of the diurnal and semi-diurnal terms; respectively. The relevant details are given in the Table below.

Table I

Relevant details of the vertical drifts (from Hirono and Maeda, 1954).

	Sunspot Max.	Sunspot Min.
W_1	1.55×10^3	1.24×10^3
W_2	0.3×10^3	0.13×10^3
θ_1	265°	280°
θ_2	171°	176°

Recently, Chandra, Gibbons and Schmerling (1960) computed the vertical drift velocities for Talara and Huancayo using the observed NmF data. These drift speeds and their phases agree well with those derived by Hirono and Maeda and given by equation (3). Incorporating this drift term Hirono and Maeda investigated the effect of such a drift on the temporal variation of NmF. They find that, under the influence of this type of vertical drift, two peaks appear in the daytime Nm(t) curve; the forenoon peak during sunspot maximum conditions and the reverse for sunspot minimum. This explanation is consistent with the experimental evidence (Sarma and Mitra, 1956).

It is, however, important to note that the effect of the vertical drift prevailing in the equatorial regions does two things. Firstly it causes two peaks to appear in the Nm(t) curve. Secondly the magnitude of either peak is below the value of the peak that would result in the absence of any vertical drift. However, this type of drift <u>does not</u> increase the forenoon or evening slopes of the Nm(t) curve. Thus, we come to the conclusion that the large slopes in the Nm(t) curves are caused by some other factor.

4.2 <u>Effects of horizontal drifts</u>

Martyn (1955) pointed out that horizontal drifts in F region for equatorial latitudes can play an important part in distorting the shape of the Nm(t) curve. Recently Hirsh and Knecht (1962), in a study of the temporal variations of the NmF at Puerto Rico, suggest that large gradients in east-west drift velocity can cause significant changes in the N(t) curve around sunrise time.

Referring to the equation of continuity (3) we may write it as

$$\frac{dN}{dt} = (q - \beta N) - v_x \frac{dN}{dx} - v_y \frac{dN}{dy} - v_z \frac{dN}{dz} - N\left(\frac{dv_x}{dx} + \frac{dv_y}{dy} + \frac{dv_z}{dz}\right) \qquad (4)$$

Here the x, y, and z axes are along east, north and upwards; respectively. If velocity gradients are neglected equation (4) becomes

$$\frac{dN}{dt} = (q - \beta N) - v_x \frac{dN}{dx} - v_y \frac{dN}{dy} - v_z \frac{dN}{dz} \qquad (5)$$

$\frac{dN}{dz}$ is positive below the F region maximum and $v_z \frac{dN}{dz}$ will be important here. The other two terms refer to the horizontal drift. The east-west drift is usually much larger than the north-south drift. Further, $\frac{dN}{dy}$ is smaller than $\frac{dN}{dx}$, particularly in the forenoon and evenings.

Since the daytime vertical drift in the equatorial regions is vertically upwards and $\frac{dN}{dz}$ is positive, this term tends to decrease $\frac{dN}{dt}$. On the other hand, if v_x is westward and in the forenoon $\frac{dN}{dx}$ is positive we find that $v_x \frac{dN}{dx}$ <u>can</u> increase $\frac{dN}{dt}$. The various possibilities of the v_x, $\frac{dN}{dx}$ terms and the resulting effect on $\frac{dN}{dt}$ are given in Table II.

<u>Table II</u>

Influence of E-W drifts on $\frac{dN}{dt}$

	Forenoon		Afternoon	
Drift	W	E	W	E
v_x	-	+	-	+
dN/dx	+	+	-	-
$v_x \frac{dN}{dx}$	-	+	+	-
(dN/dt)	+		-	
effect on $\frac{dN}{dt}$	increase	decrease	decrease	increase

In Fig. 9 (Rao 1963 published work) the broken line illustrates the effect of a westward sinusoidal drift velocity with an amplitude of about 200 m/s and having the same phase as the sun. It is seen that this type of drift substantially alters the shape of the forenoon Nm(t) curve. The forenoon slope is considerably increased and the N(t) maximum is shifted towards forenoon hours.

In order to apply these considerations to practical observations we shall, in the next section, examine the experimental evidence on F region horizontal drifts and obtain a prevailing drift model.

4.3 Model of the horizontal F region drift pattern in low latitudes

Observational evidence on horizontal drifts in the F region is available from two types of experiments. One of them is Mitra's (1949) fading method which essentially gives information concerning systematic horizontal drifts or irregularities of 'wavelength' less than a few kilometers. The travelling disturbances (Munro, 1950) are large scale irregularities with scale of the order of several hundred kilometers. The observational data on the F region horizontal drifts using the two techniques is summarised by Briggs (1962) as follows

East-West drifts: During daytime the drift direction is westward and the drift speed is about 100 m/s; at night the drift is eastward with a speed of the same order of magnitude.

North-South drift: The north-south drift is always directed towards the equator during the night. The daytime results are not conclusive but indicate that the opposite is probably true during daytime. The speed of the N-S drift component is of the order of 50 m/s.

A significant feature of the E-W component is that it shows rapid reversals of direction in a matter of an hour or so around sunrise and sunset times (Rao and Rao, 1958; Lyon, Skinner and Wright, 1960). Also, near the magnetic equator, the horizontal F region drift speeds are found to decrease during disturbed days (Lyon et al, 1960; Rao et al, 1962).

The average directions and magnitudes of the velocities of travelling disturbances are similar to those observed by the fading method except in that the N-S component of motion seems to be larger than that observed with the fading method and is subject to a marked seasonal variation.

We shall adopt the following drift pattern for equinoctial conditions consistent with the experimental evidence presented above. The daytime drift is westwards and is eastwards during the night with rapid changes in direction occurring around sunrise and sunset periods. The drift speeds are of the order of 100 m/s, i.e. about five times as great as the vertical drift speeds (Chandra, Gibbons and Schmerling, 1960).

4.4 Explanation of the slopes of the N(t) curve

Following sunrise, the E-W drift changes direction from eastward to westwards in a matter of one hour. Thus, in the forenoon hours there are present large horisontal velocity and electron density gradients in the east-west direction. The effective westward drift at this time is of the order of 200 m/s. According to the arguments presented in section 4.2, and referring to Fig. 9, it is seen that, under the influence of the westward drift and its gradient, a considerable increase in the forenoon slopes may be expected. This increased slope may be maintained for several hours under the influence of the constant westward drift of the order of 100 m/s while the vertical drifts at these times are small.

In the evenings $\frac{dN}{dt}$ is negative. Again rapid changes of the drift directions at this time may then be seen to increase $\frac{dN}{dt}$. As a consequence the minimum value of N_m reached just after sunset would be lowest when maximum $\frac{dN}{dt}$ is produced.

Since the seasonal pattern of the horisontal drifts is not very certain detailed interpretation of the seasonal variation has to be deferred until a definite seasonal pattern of the horisontal drifts is established. It may be noted that the pattern of horisontal drift data described in section 4.3 is essentially the same as what one might expect from electrodynamic effects of the Sq-current system (Martyn 1955). Thus we may infer that the seasonal variation of these electrodynamic effects would be reflected in the observed slopes of the $N(t)$ curve as a semiannual variation.

4.5 Interpretation of the post-sunset rise in F region heights

Appleton and Lyon (1955) have shown that under the influence of a vertical drift the change in the height of the maximum of the F region is of the order of $v\tau$ where τ is the relaxation time of the region. Now τ is inversely proportional to N_m. Thus we note that the change in height is inversely proportional to N_m and directly proportional to the vertical drift speed. It is easily noted that the <u>rate of change</u> of height is directly proportional to $\frac{dN_m}{dt}$ and inversely proportional to the square of N_m.

The maximum $\frac{dN_m}{dt}$ occurs around the equinoxes. Also the minimum value of N_m just after sunset also occurs about the same period; both under the influence of horizontal drifts. Under these conditions when a vertical drift is effective we can easily see that the largest height change, combined with largest rate of change of height, will occur. Thus, the rapid rise in the post-sunset heights, as well as the seasonal variations in the magnitude of the post-sunset rise, may be satisfactorily explained.

It has been mentioned in section 4.3 that during disturbed days there is evidence that the horizontal drift velocities are reduced. This reduction can, in turn, cause a decrease in the magnitude of the post-sunset rise in heights.

5. Conclusions

From the foregoing discussion we conclude that, in the equatorial regions, the horizontal drifts combined with the vertical drifts can explain several of the 'anomalies'. This may be extended to the explanation of other phenomena such as spread F and the origin of flutter fading which show seasonal dependence similar to those exhibited by NmF and F-region heights. Lastly, it may be mentioned that the diurnal variation of temperature proposed by Van Zandt and Norton may also contribute to these features.

Acknowledgments

The author wishes to express his thankfulness to Mr. B. C. N. Rao of the Radio Propagation Unit, N.P.L., New Delhi, for much help rendered and for several useful discussions.

References

1. Appleton, E. V., Nature (Lond) 157, 691, (1946).

2. Appleton, E. V., Some Ionospheric Results Obtained During IGY. Elsevier Publication (1960) pp. 3-7.

3. Appleton, E. V. and Lyon, A. J., Physics of the Ionosphere, Physical Society, Lond., p. 20, (1955).

4. Briggs, B. H., Ionospheric Radio, Elsevier Publication, pp. 219-239, (1962).

5. Chandra, S., Gibbons, J. J. and Schmerling, E. R., J. Geophys. Res., 65, 1159-1175, (1960).

6. Hirono, M. and Maeda, H., J. Geomag. and Geolect., 6, 122-144, (1954).

7. Hirsh, A. J. and Knecht, R. W., J. Geophys. Res., 67, 595-600, (1962).

8. Lyon, A. J., Skinner, W. and Wright, R. W., Some Ionospheric Results Obtained During IGY, Elsevier Publication, (1960), p. 333.

9. Maeda, H. J., Geomag. and Geolect., 6, 121, (1955).

10. Martyn, D. F., Proc. Roy. Soc., A 189, 241, (1947).

11. Martyn, D. F., Physics of the Ionosphere, Physical Society, p. 260, (1955).

12. Mitra, S. N., Proc. Inst. Elec. Engrs. (London), 96, Pt. III, 441, 1949.

13. Munro, G. H., Proc. Roy. Soc. (London), A 202, 208, (1950).

14. Osborne, B. W., J. Atm. and Terr. Phys., 2, 66, (1951).

15. Rao, B. C. N., R. P. U. Sci. Rep. No. 9, (1962).

16. Rao, B. C. N., Unpublished work (1963).

17. Rao, B. R. and Rao, E. B., Nature, 81, 1612, (1958).

18. Rao, B. R., Rao, E. B. and Murty, Y. V. R., Proc. of IGY Symposium, Vol. 1, CSIR, India, 205-211, (1962).

19. Sarma, N. V. G. and Mitra, A. P., J. Sci. Ind. Res., (India), 15B, 320, (1956).

20. Schmerling, E. R., Penn. State Univ., Ionosphere Research Lab., Sci. Rep. No. 94, (1957).

21. Schmerling, E. R., Ionospheric Radio, Elsevier Publication, (1962) pp. 16-20.

22. Smith, E. K. and Finney, J. W., J. Geophys. Res., 65, 855-892, (1960).

23. Somayajulu, Y. V., J. Geophys. Res., 68, 1899-1922, (1963).

24. Subba Rao, N. S. and Somayajulu, Y. V., Nature, 163, 442, (1949).

PSU SR 192

It is established that east-west drifts, such as those observed experimentally, can cause large variations in these slopes. A seasonal variation of the wind pattern may account for the observed seasonal variation.

On this model the phenomenon of the post sunset increase in F region heights, and its seasonal variation, is explained. It is indicated that several other equatorial phenomena such as Spread F and flutter fading can be explained on this basis. It is concluded that, in the equatorial regions, the ionospheric electrostatic fields play a dominant part in causing the equatorial 'anomalies'.

PSU

PSU SR 192

It is established that east-west drifts, such as those observed experimentally, can cause large variations in these slopes. A seasonal variation of the wind pattern may account for the observed seasonal variation.

On this model the phenomenon of the post sunset increase in F region heights, and its seasonal variation, is explained. It is indicated that several other equatorial phenomena such as Spread F and flutter fading can be explained on this basis. It is concluded that, in the equatorial regions, the ionospheric electrostatic fields play a dominant part in causing the equatorial 'anomalies'.

PSU

PSU SR 192

It is established that east-west drifts, such as those observed experimentally, can cause large variations in these slopes. A seasonal variation of the wind pattern may account for the observed seasonal variation.

On this model the phenomenon of the post sunset increase in F region heights, and its seasonal variation, is explained. It is indicated that several other equatorial phenomena such as Spread F and flutter fading can be explained on this basis. It is concluded that, in the equatorial regions, the ionospheric electrostatic fields play a dominant part in causing the equatorial 'anomalies'.

PSU

PSU SR 192

It is established that east-west drifts, such as those observed experimentally, can cause large variations in these slopes. A seasonal variation of the wind pattern may account for the observed seasonal variation.

On this model the phenomenon of the post sunset increase in F region heights, and its seasonal variation, is explained. It is indicated that several other equatorial phenomena such as Spread F and flutter fading can be explained on this basis. It is concluded that, in the equatorial regions, the ionospheric electrostatic fields play a dominant part in causing the equatorial 'anomalies'

PSU

PSU SR 192

The Pennsylvania State University, University Park, Penna.

SOME FEATURES OF THE F REGION ELECTRON DENSITY AND HEIGHT VARIATIONS IN THE EQUATORIAL REGIONS

by Y. V. Somayajulu, September, 1963. 27 pp.

AFCRL-63-817 Unclassified Report

In this report are presented the average quiet day variations in NmF and h(.9NmF) for the equatorial stations Talara and Huancayo, derived from the true-height profiles for the five international quiet days for each of the IGY months. The results show that the forenoon and evening slopes of the Nm(t) curves, as well as the post-sunset increase in the F region heights, have similar semiannual variations. It is established that this semiannual variation has a close correlation with the variation of the cosine of the noon solar zenith angle of the sun, indicating that electrodynamic drifts are important in producing the observed seasonal variation. It is shown that vertical drifts alone are inadequate to account for the large slopes in the Nm(t) curves.

I. Y. V. Somayajulu
II. The Pennsylvania State University
III. PSU SR 192

PSU SR 192

The Pennsylvania State University, University Park, Penna.

SOME FEATURES OF THE F REGION ELECTRON DENSITY AND HEIGHT VARIATIONS IN THE EQUATORIAL REGIONS

by Y. V. Somayajulu, September, 1963. 27 pp.

AFCRL-63-817 Unclassified Report

In this report are presented the average quiet day variations in NmF and h(.9NmF) for the equatorial stations Talara and Huancayo, derived from the true-height profiles for the five international quiet days for each of the IGY months. The results show that the forenoon and evening slopes of the Nm(t) curves, as well as the post-sunset increase in the F region heights, have similar semiannual variations. It is established that this semiannual variation has a close correlation with the variation of the cosine of the noon solar zenith angle of the sun, indicating that electrodynamic drifts are important in producing the observed seasonal variation. It is shown that vertical drifts alone are inadequate to account for the large slopes in the Nm(t) curves.

I. Y. V. Somayajulu
II. The Pennsylvania State University
III. PSU SR 192

PSU SR 192

The Pennsylvania State University, University Park, Penna.

SOME FEATURES OF THE F REGION ELECTRON DENSITY AND HEIGHT VARIATIONS IN THE EQUATORIAL REGIONS

by Y. V. Somayajulu, September, 1963. 27 pp.

AFCRL-63-817 Unclassified Report

In this report are presented the average quiet day variations in NmF and h(.9NmF) for the equatorial stations Talara and Huancayo, derived from the true-height profiles for the five international quiet days for each of the IGY months. The results show that the forenoon and evening slopes of the Nm(t) curves, as well as the post-sunset increase in the F region heights, have similar semiannual variations. It is established that this semiannual variation has a close correlation with the variation of the cosine of the noon solar zenith angle of the sun, indicating that electrodynamic drifts are important in producing the observed seasonal variation. It is shown that vertical drifts alone are inadequate to account for the large slopes in the Nm(t) curves.

I. Y. V. Somayajulu
II. The Pennsylvania State University
III. PSU SR 192

PSU SR 192

The Pennsylvania State University, University Park, Penna.

SOME FEATURES OF THE F REGION ELECTRON DENSITY AND HEIGHT VARIATIONS IN THE EQUATORIAL REGIONS

by Y. V. Somayajulu, September, 1963. 27 pp.

AFCRL-63-817 Unclassified Report

In this report are presented the average quiet day variations in NmF and h(.9NmF) for the equatorial stations Talara and Huancayo, derived from the true-height profiles for the five international quiet days for each of the IGY months. The results show that the forenoon and evening slopes of the Nm(t) curves, as well as the post-sunset increase in the F region heights, have similar semiannual variations. It is established that this semiannual variation has a close correlation with the variation of the cosine of the noon solar zenith angle of the sun, indicating that electrodynamic drifts are important in producing the observed seasonal variation. It is shown that vertical drifts alone are inadequate to account for the large slopes in the Nm(t) curves.

I. Y. V. Somayajulu
II. The Pennsylvania State University
III. PSU SR 192